Hellenic Institute of Nuclear Physics

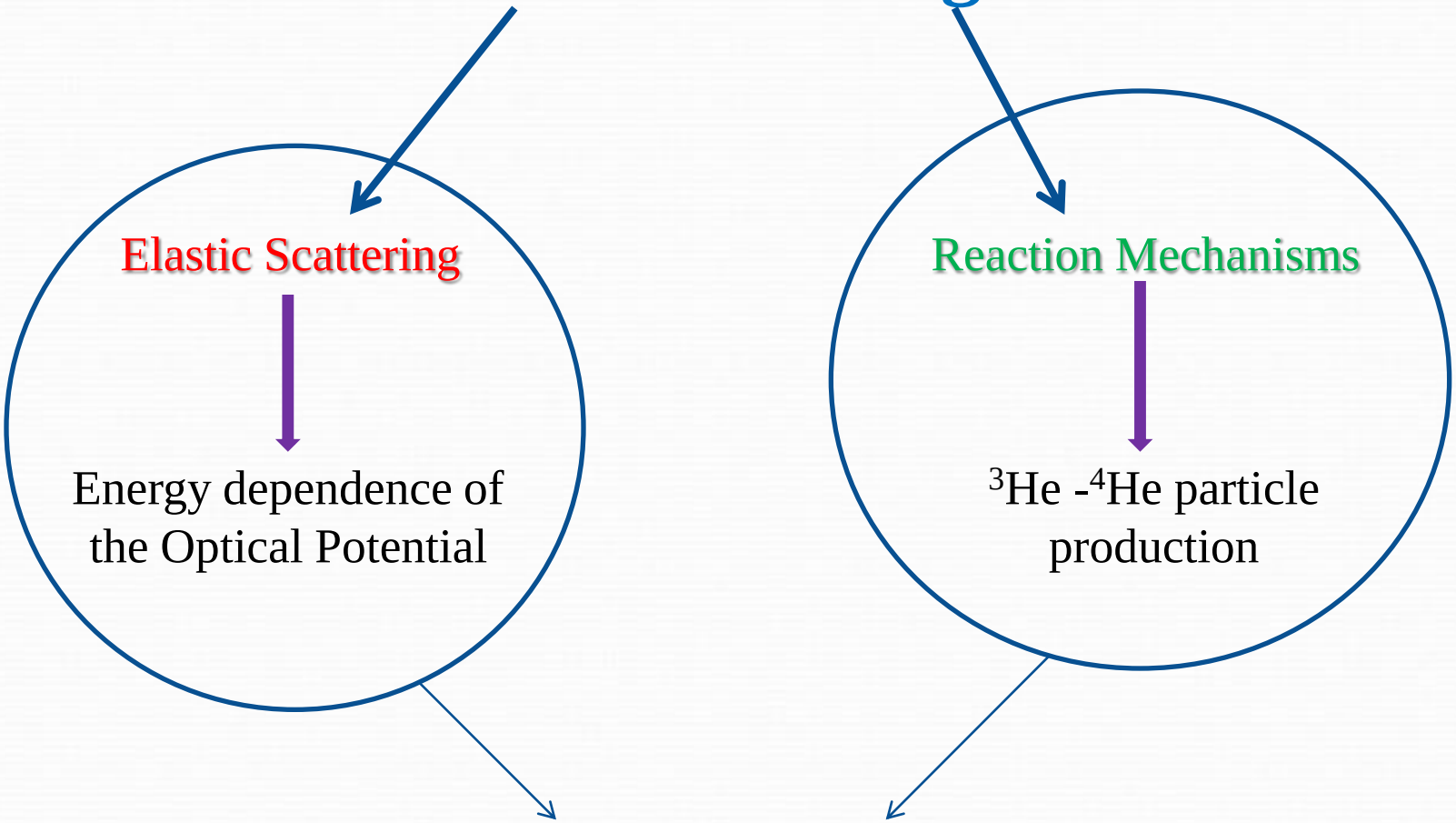
The 3rd Workshop of the Hellenic Institute of Nuclear Physics

Alpha and ^{3}He – particle production in the reaction ^{7}Be+^{28}Si at near barrier energies

Onoufrios Sgouros
University of Ioannina

8th of April, 2016, Athens, Greece

Study of the reaction $^{7}Be+^{28}Si$ at near barrier energies



Goal: The description of both data sets into the Coupled Channels context

The Experiment

- The study of the **elastic scattering** and the **relevant reaction mechanisms** for the system **^{7}Be+^{28}Si** was performed at near barrier energies, namely at 13, 20 and 22 MeV corresponding to (1.1-1.9)$V_{C.b}$, in order to study the energy dependence of the optical potential as well as the influence of the reaction channels on the elastic scattering.

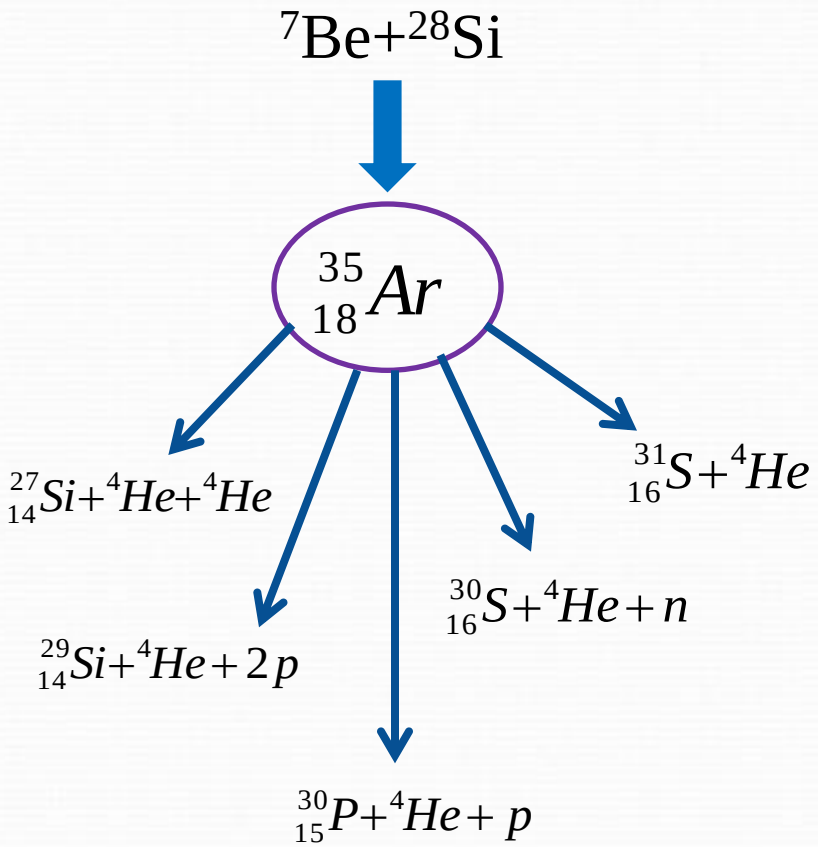
Reaction Mechanisms

(^{4}He and ^{3}He particle production)

Direct Reactions

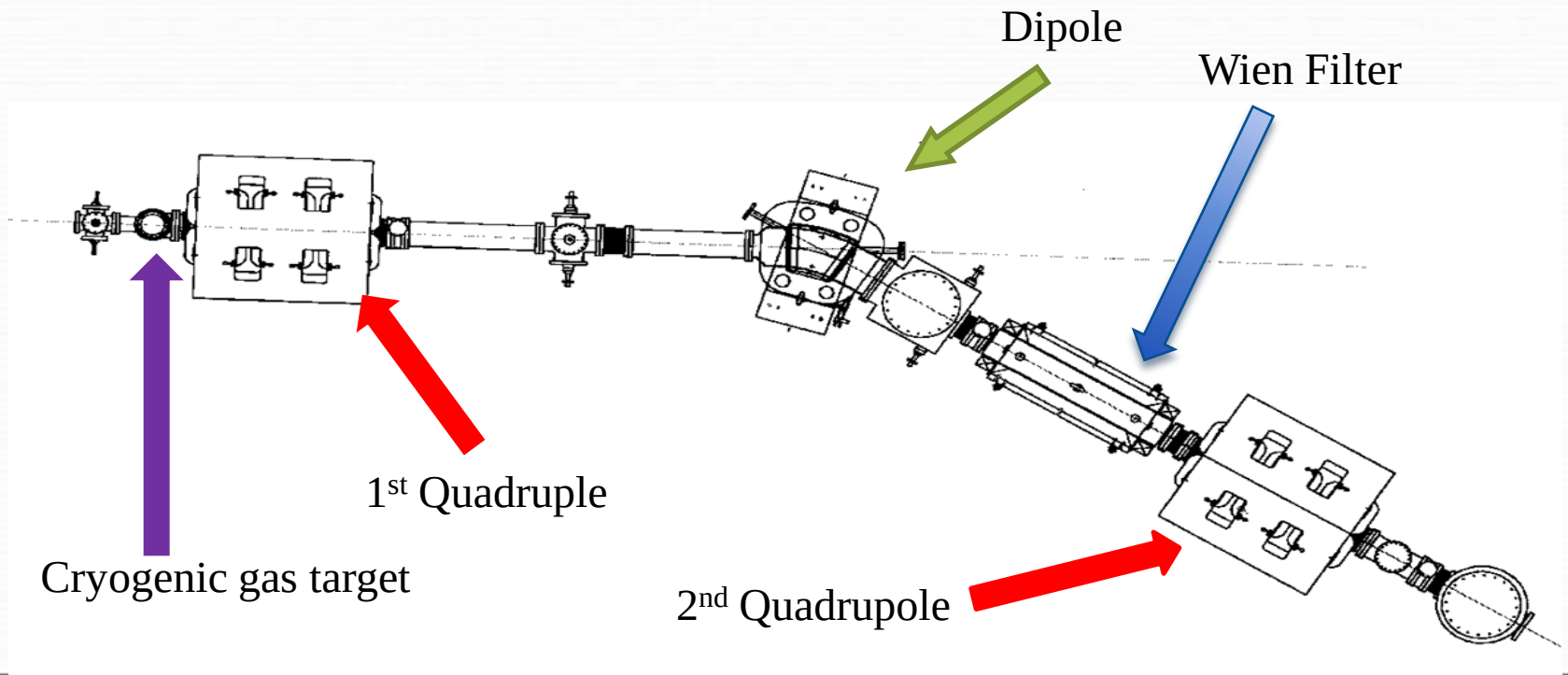
- $^{7}Be+^{28}Si \rightarrow {}^{6}Be+^{29}Si \rightarrow {}^{4}He+p+p$
- $^{7}Be+^{28}Si \rightarrow {}^{8}Be+^{27}Si \rightarrow {}^{4}He+{}^{4}He$
- $^{7}Be+^{28}Si \rightarrow {}^{4}He+{}^{31}S$
- $^{7}Be+^{28}Si \rightarrow {}^{3}He+{}^{32}S$
- $^{7}Be+^{28}Si \rightarrow {}^{4}He+{}^{3}He+{}^{28}Si$

Compound nucleus reactions

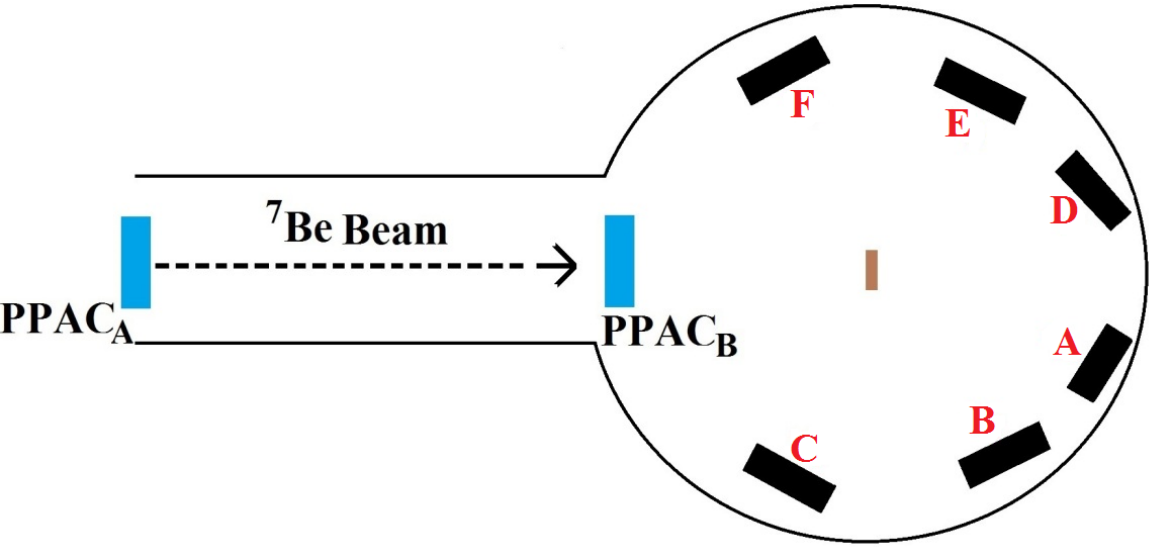


The EXOTIC facility

- The experiment was visualized at the EXOTIC facility at the Laboratori Nazionali di Legnaro (LNL, Italy).
- ^{7}Be production: In flight technique via the p(^{7}Li,^{7}Be)n reaction ($Q_{val.}$=-1.64 MeV).



Experimental Setup



Telescope ID	Angular range (Degrees)
A	14.17 – 39.83
B	53.51 – 84.49
C	96.05 – 125.95
D	13.03 – 40.97
E	53.51 – 84.49
F	94.78 – 127.22

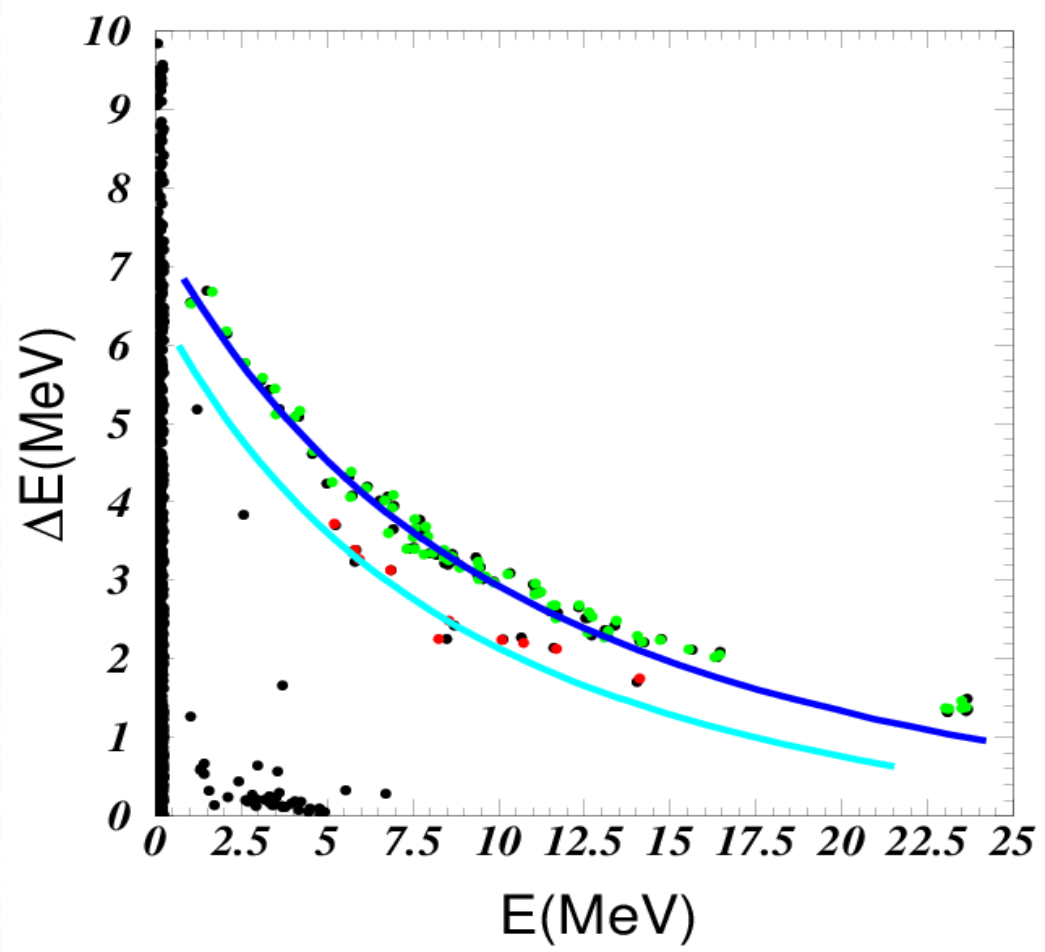
EXPADES Telescope

DSSSD 50μm : ΔE

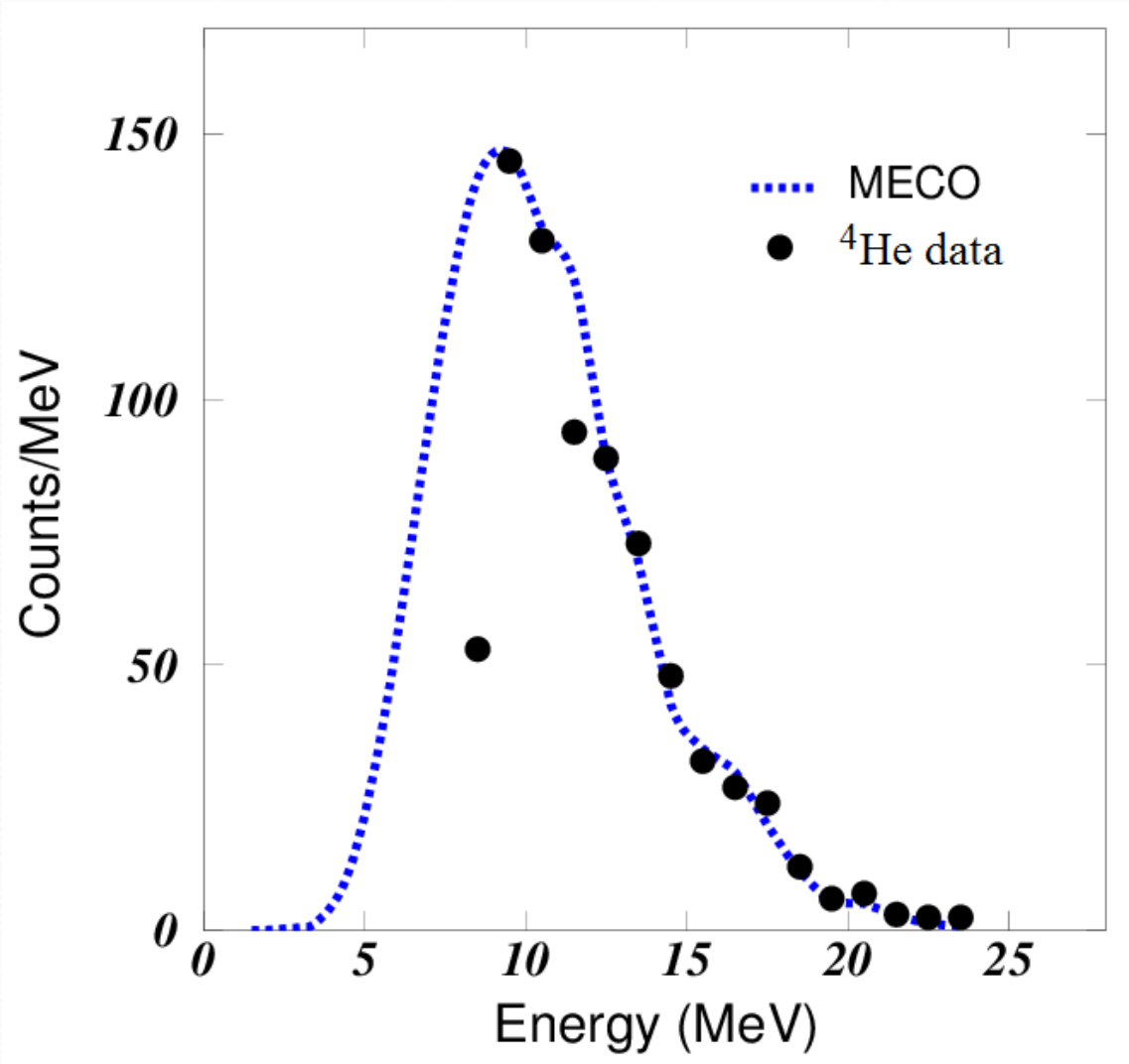
+

DSSSD 300 μm: E_{res}

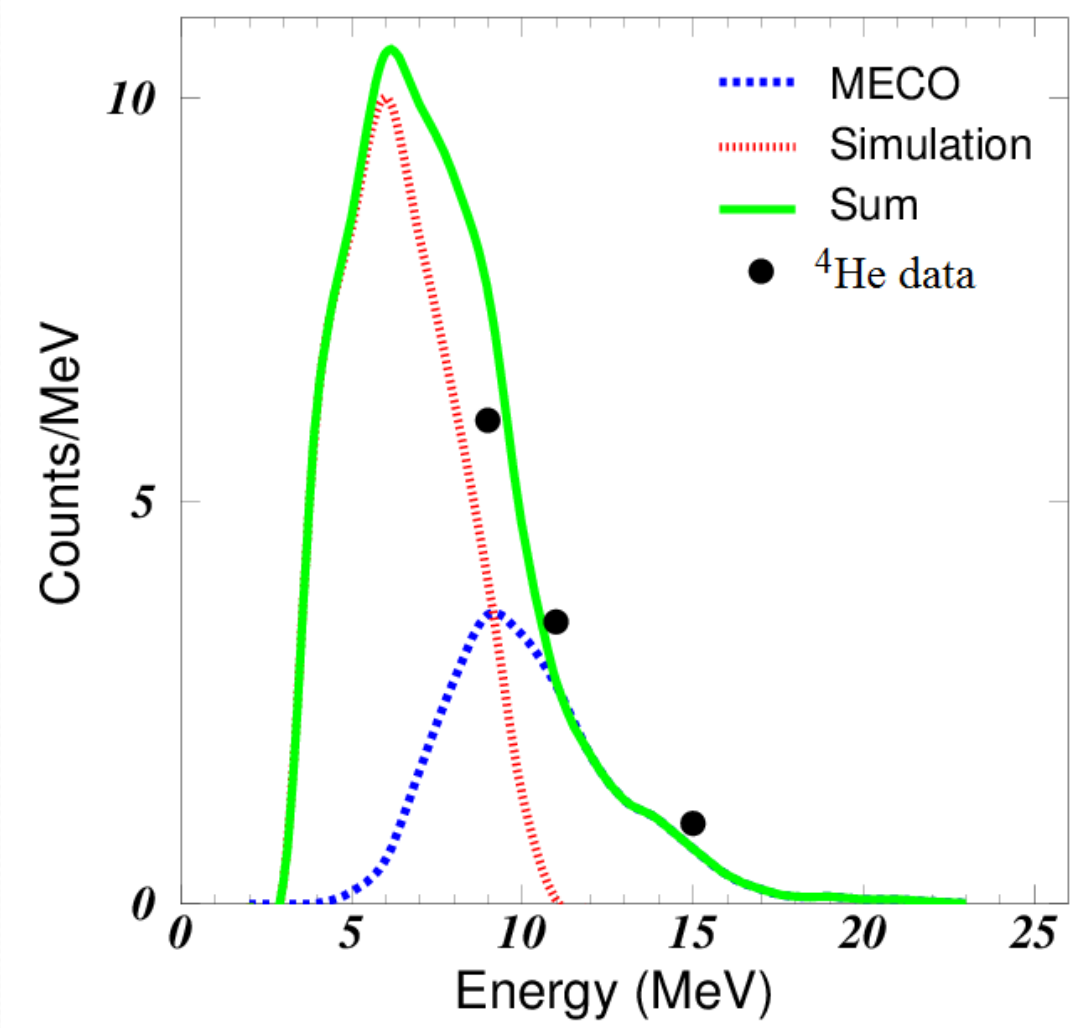
Identification of ^{3}He and ^{4}He reaction products at 22 MeV



^{4}He particles energy distribution at 22 MeV



^{4}He particles energy distribution at 13 MeV



The simulation code

- Monte Carlo technique: Events are randomly generated and they are filtered by constrains.

K. K. Olimov et al.,
Int. J. Mod. Phys. E 25, 1650021 (2016)

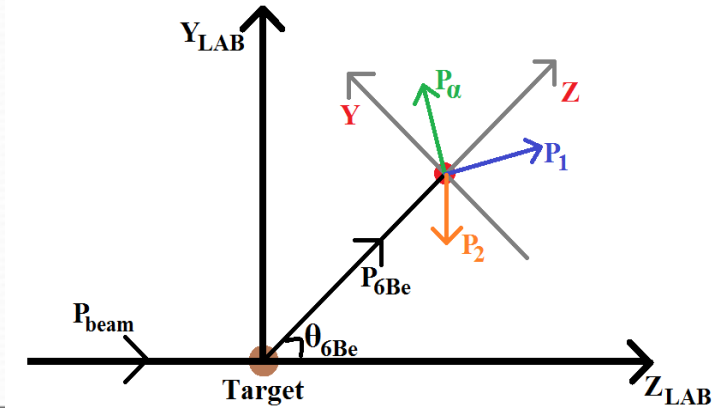
- 1st step: Construction of pairs (θ_{6Be},P_{6Be}) in the center of mass system.

Constrain: The ^{6}Be angular distribution obtained via code FRESCO.

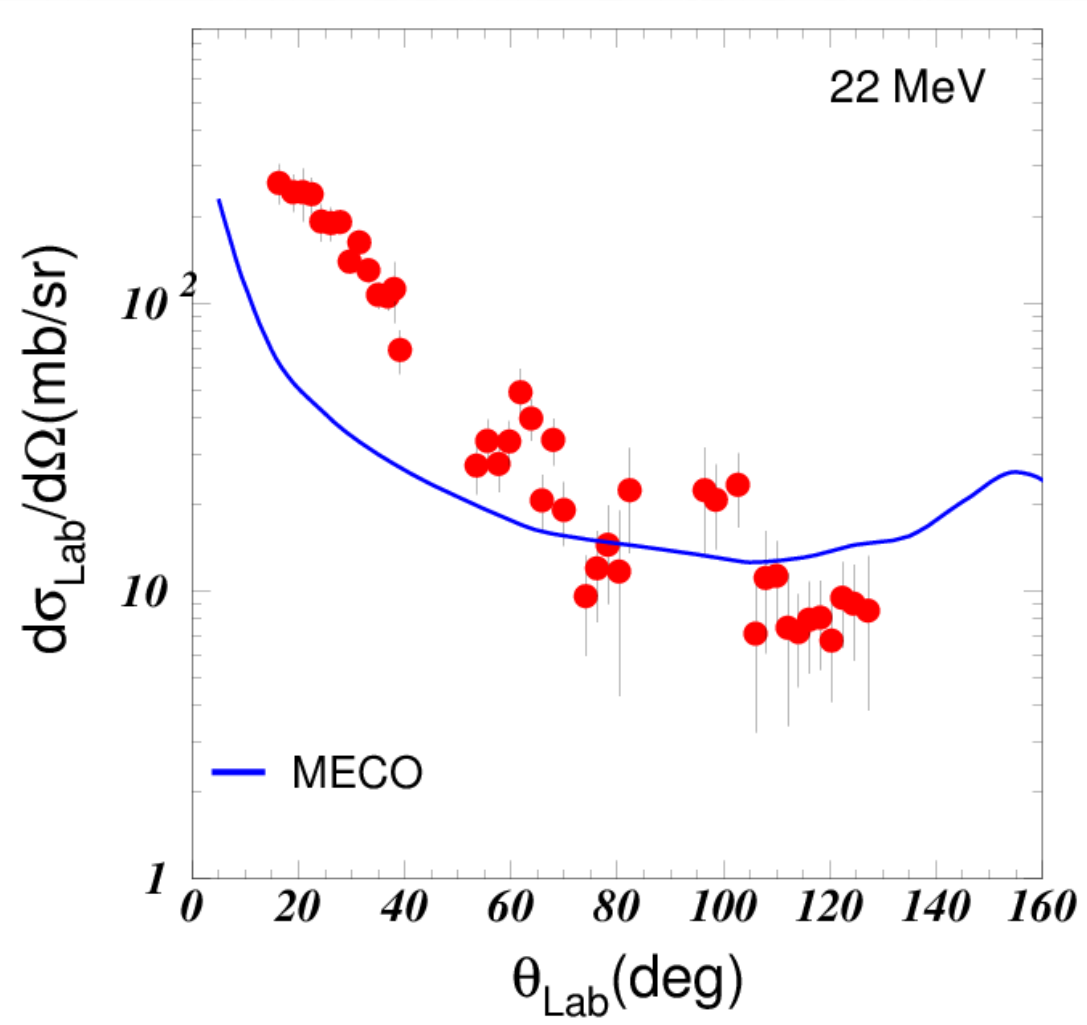
- 2nd step: Construction of triplets (E_α,E_1,E_2) and (P_{xi},P_{yi},P_{zi}) for each fragment in the rest frame of ^{6}Be nucleus.

Constrains: The energy and the momentum conservation.

- 3rd step: Transformation of (P_{xi},P_{yi},P_{zi}) in the laboratory reference frame through a Galilean transformation and a two dimensional axes rotation.

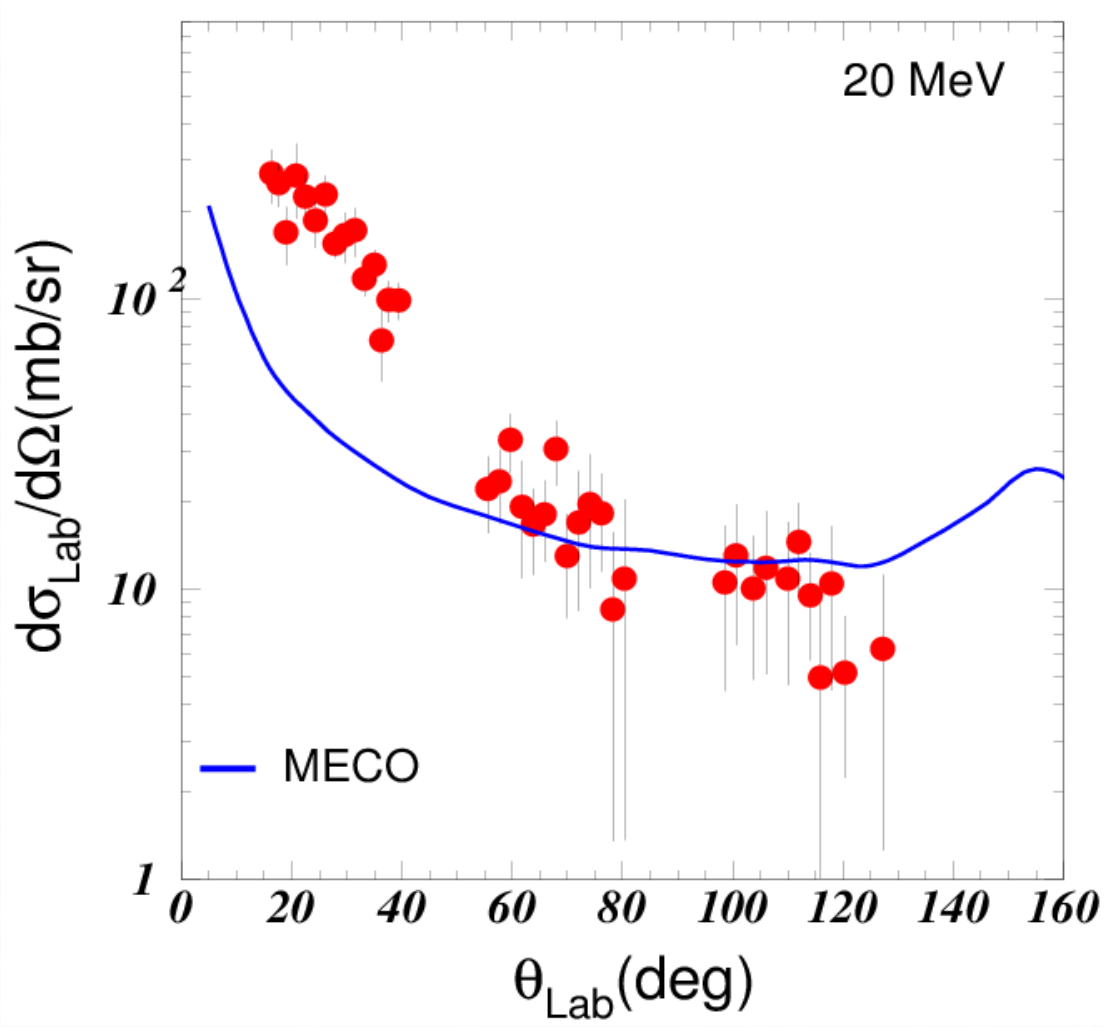


^{4}He angular distribution data at the energy of 22 MeV

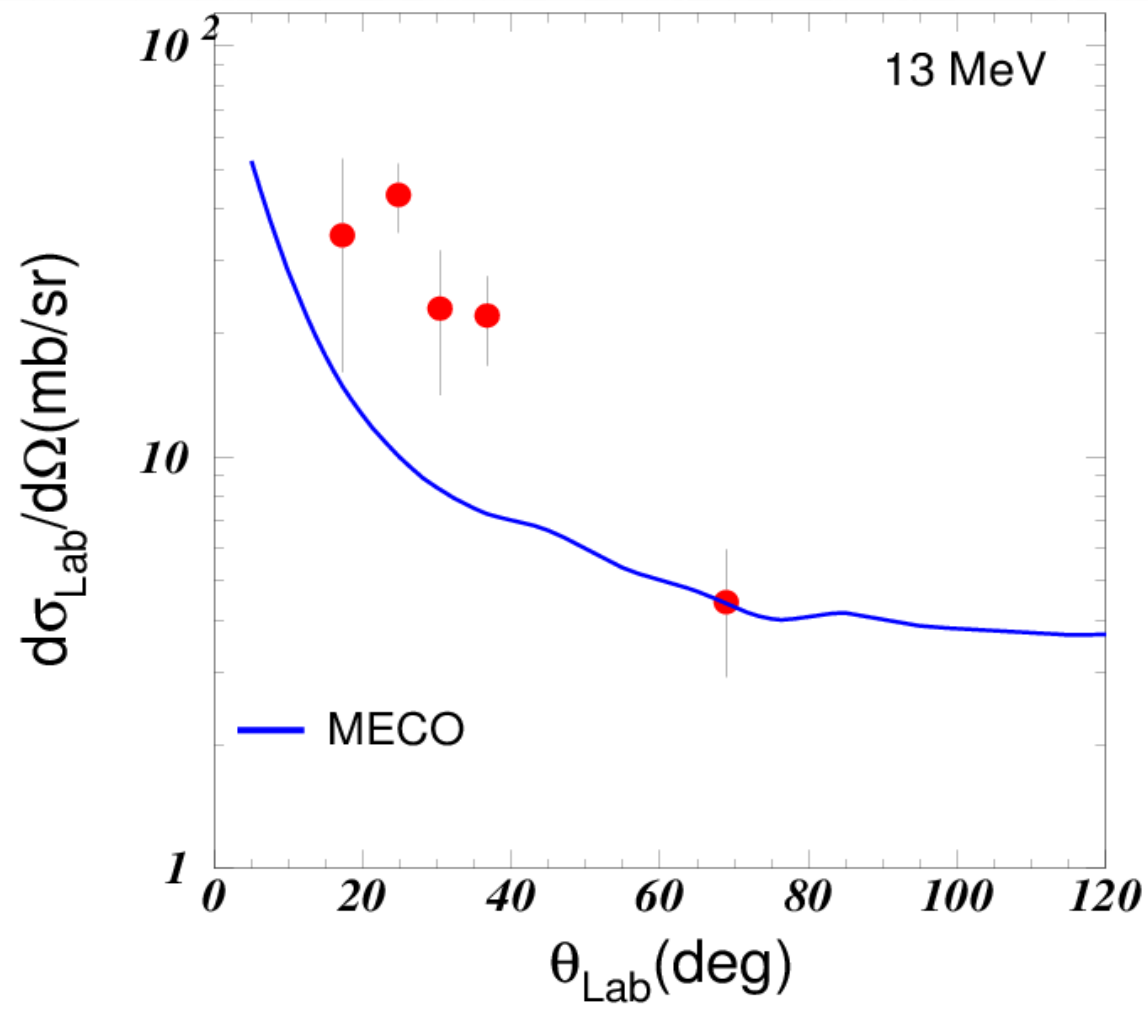


A. Pakou et al.
PRC 71, 064602
(2005)

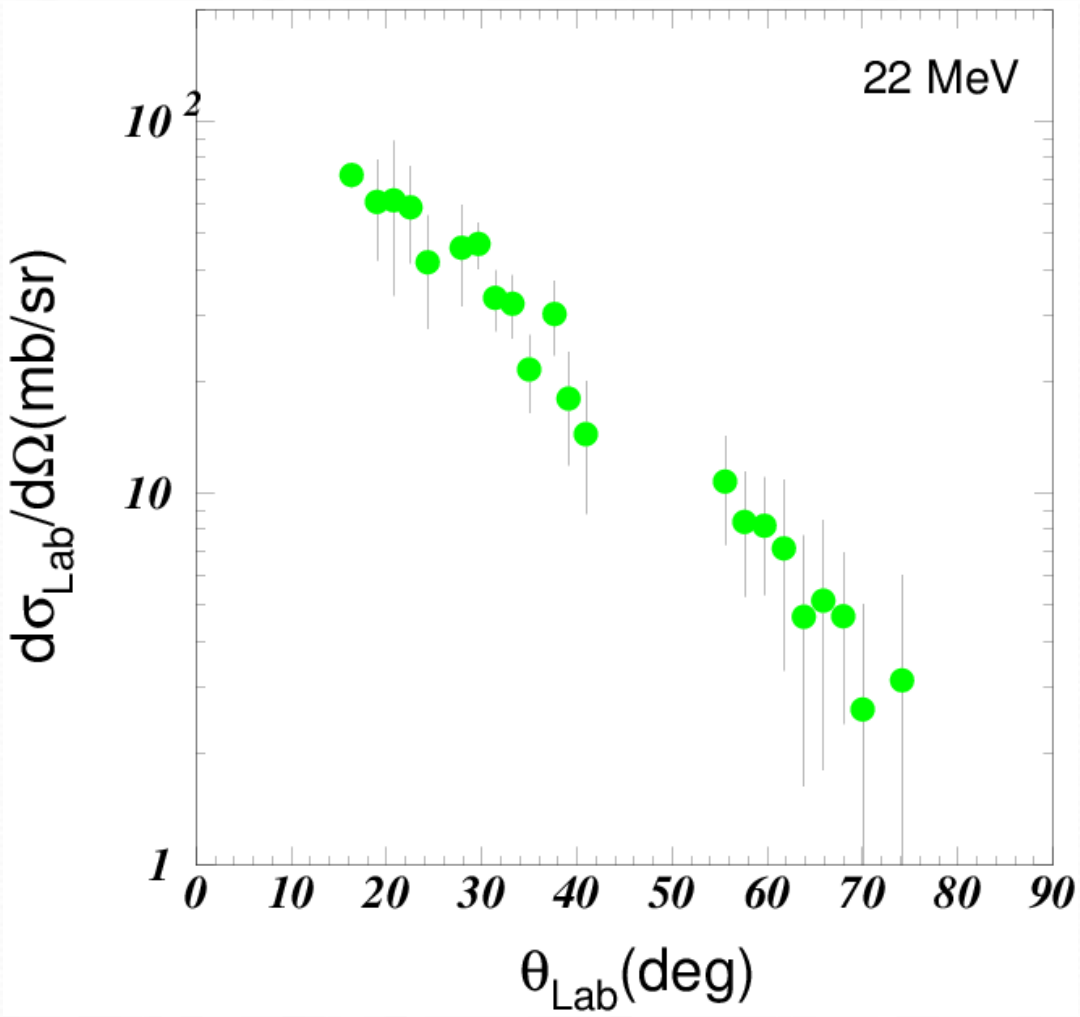
^{4}He angular distribution data at the energy of 20 MeV



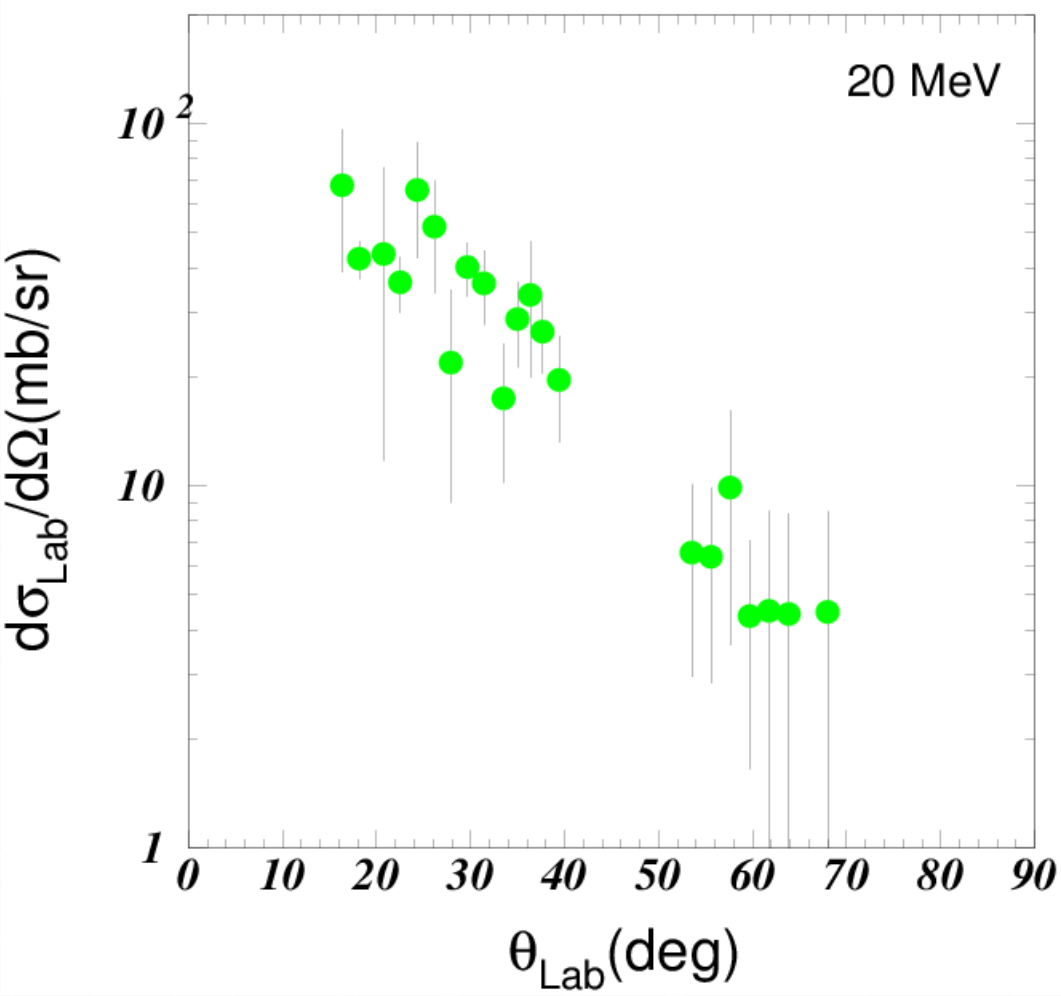
^{4}He angular distribution data at the energy of 13 MeV



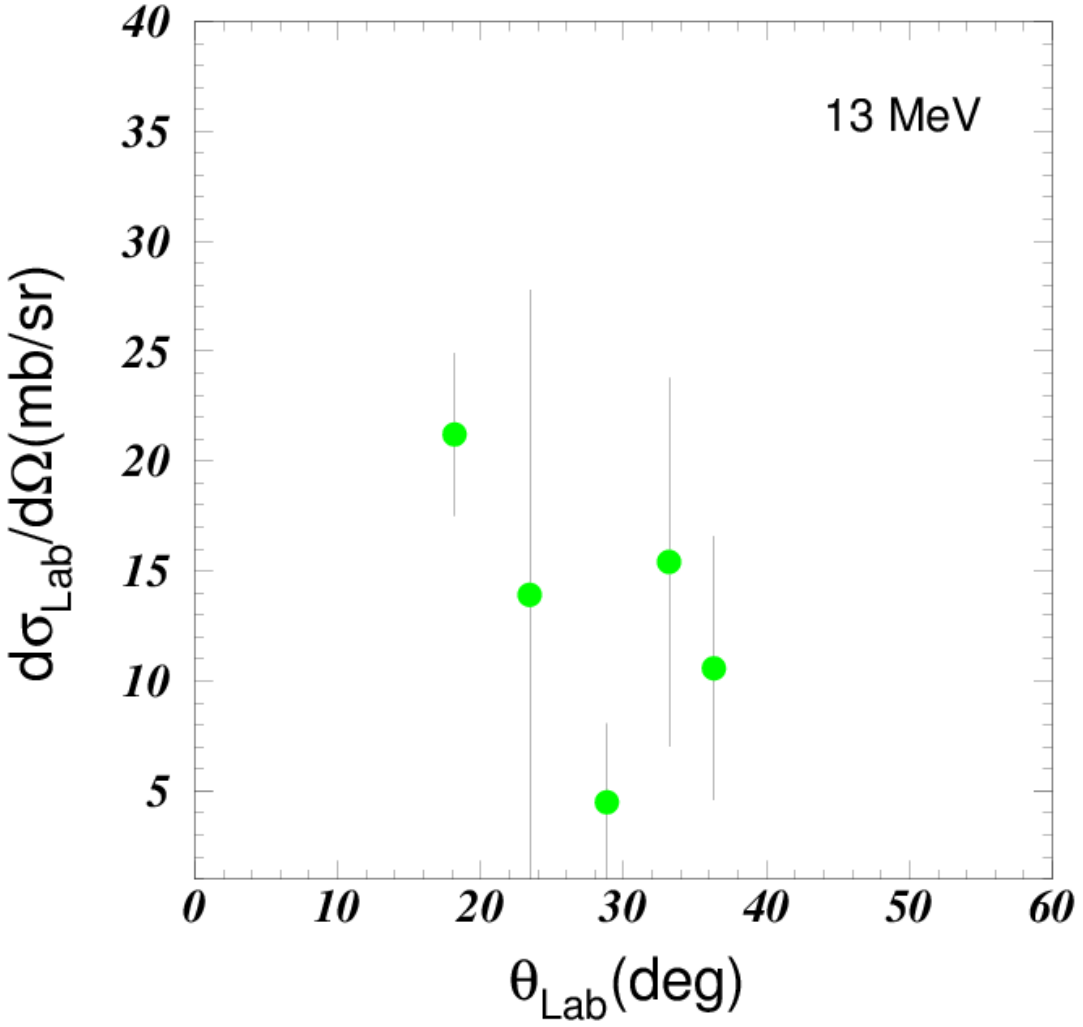
^{3}He angular distribution data at the energy of 22 MeV



^{3}He angular distribution data at the energy of 20 MeV



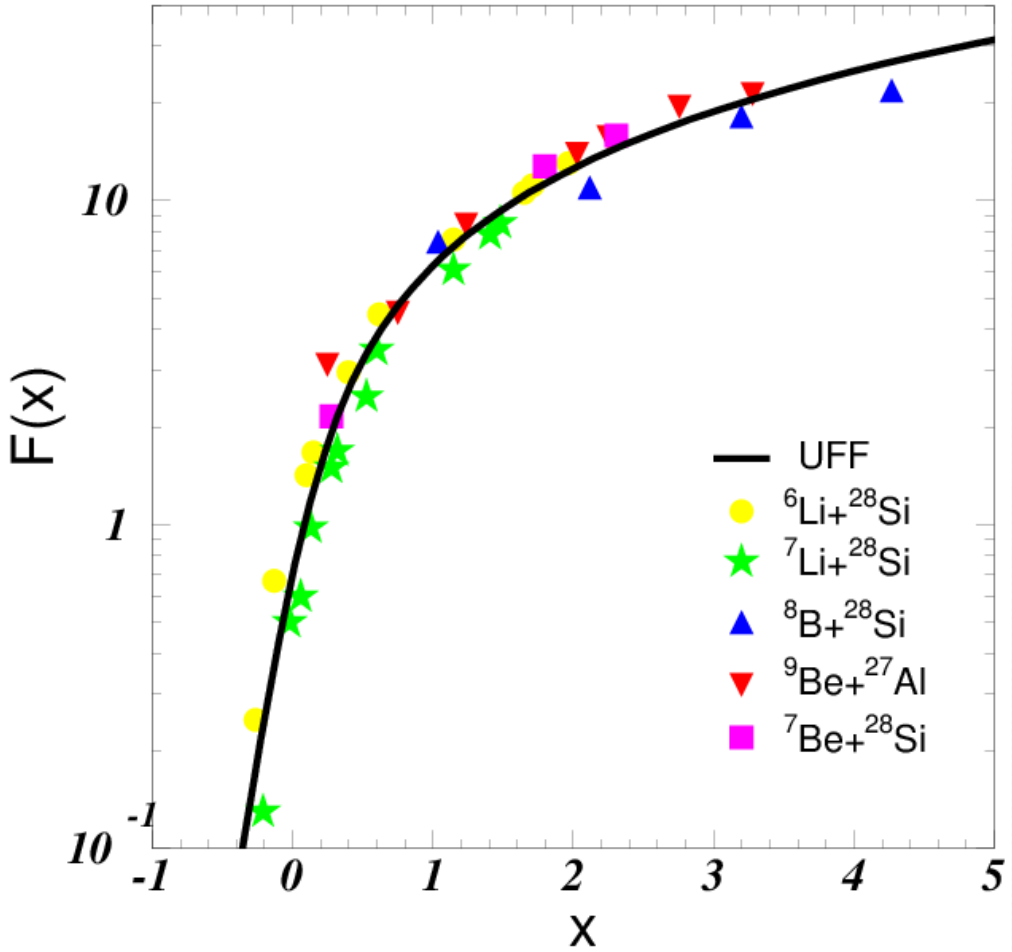
^{3}He angular distribution data at the energy of 13 MeV



Energy (MeV)	^{4}He originating from direct processes (mb)	^{4}He originating from compound processes (mb)	Alpha particle multiplicities in the compound framework	Fusion (mb)
22	258	255	0.255	1000
20	218	239	0.268	893
13	34	69	0.304	228

Fusion cross sections for the system $^{7}Be+^{28}Si$

A. Pakou et al., PRC 87, 014619 (2013); EPJA 51, 55 (2015)



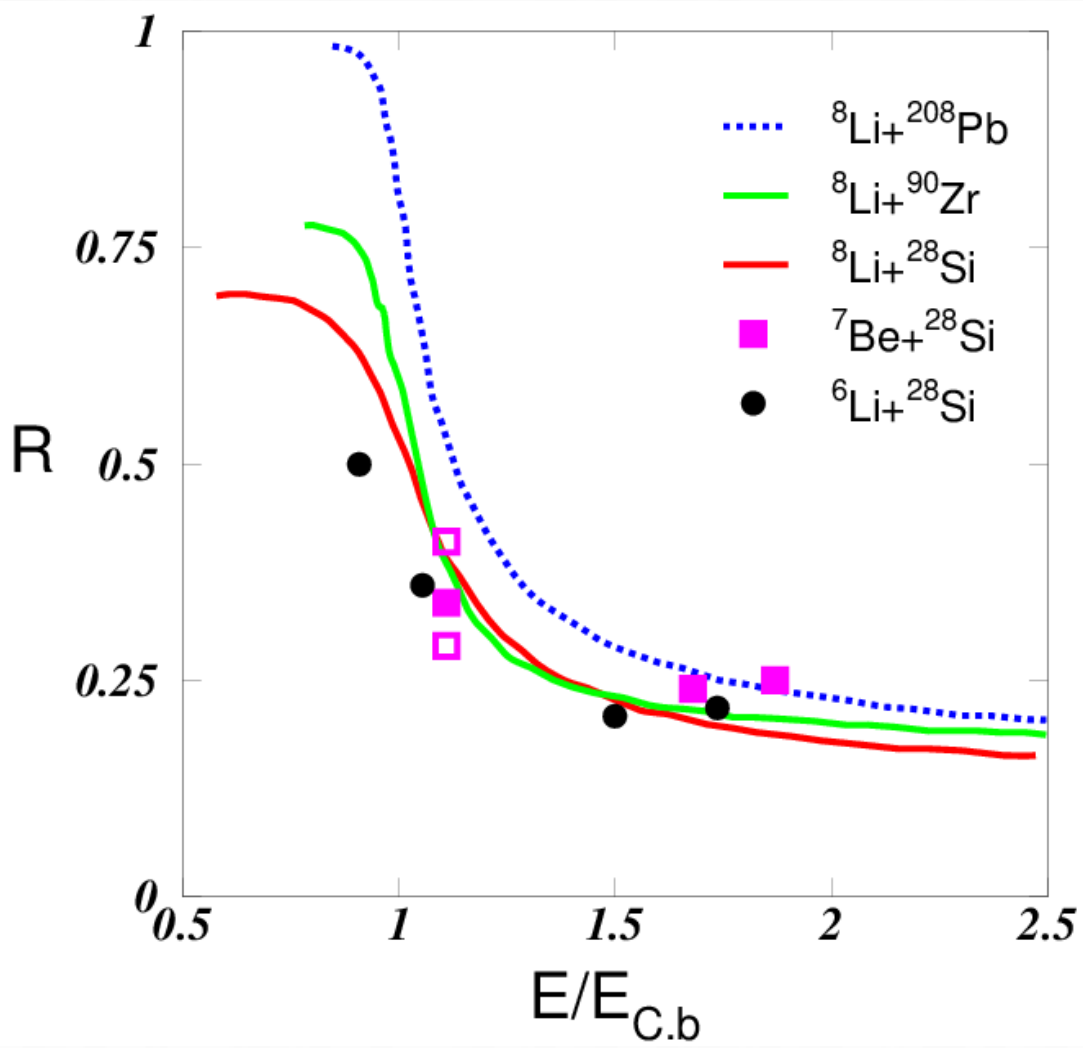
L.F. Canto et al., NPA 821, 51 (2009)

$$\sigma_F \rightarrow F(x) = \frac{2E_{c.m}}{\hbar\omega R_B^2}\sigma_F$$

$$E_{c.m} \rightarrow x = \frac{E_{c.m} - V_B}{\hbar\omega}$$

The ratio R= Direct reactions cross section / Total reaction cross section

A. Pakou et al.
EPJA 51, 55 (2015)



Summary

- Angular distribution measurements for ^{3}He and ^{4}He ions were performed for the system $^{7}Be+^{28}Si$ at near barrier energies namely 13, 20 and 22 MeV.
- Angular distribution data of ^{3}He and ^{4}He were presented at 3 near barrier energies. The ^{4}He data were treated in a statistical model framework and the contribution of the direct and the compound nucleus mechanisms to the total alpha production was estimated.
- The ratio R(direct to total) was calculated for the system $^{7}Be+^{28}Si$ and it was found that present data are in reasonable agreement with previous measurements exhibiting an increasing behavior of the ratio while approaching the barrier.
- Taking into account ^{4}He production due to compound processes and alpha particles multiplicities in the compound framework, fusion cross sections were deduced presenting excellent agreement with the systematics indicating that fusion is a process which can be well described by a one-barrier penetration model theory.
- **Under Progress: The description of both elastic scattering and reaction data into the Coupled Channels framework.**

Collaborators

- *Physics Department and HINP, The University of Ioannina, Ioannina, Greece*
- *Departimento di Fisica and INFN – Sezione di Padova, Padova, Italy*
- *INFN – Sezione di Napoli, Napoli, Italy*
- *INFN – Sezione di Milano, Milano, Italy*
- *INFN, Sezione di Catania, Catania, Italy*
- *Dipartimento di Scienze Fisiche, Universita di Napoli, Napoli, Italy*
- *Departamento di Fisica Aplicada, Universidad de Huelva, Huelva, Spain*
- *National Center for Nuclear Research, Warsaw, Poland*
- *Heavy Ion Laboratory, University of Warsaw, Warsaw, Poland*
- *Centro de Fisica Nuclear da Universidade de Lisboa, Portugal*
- *Institute of Accelerating Systems and Applications and Department of Physics, University of Athens, Greece*